Development and Application of NASA SPoRT's DustTracker-AI model for Real-time Identification and Tracking of Dust in Geostationary Satellite Imagery

Connor H. Welch[1], Robert A. Junod[1], E.B. Berndt[2], K. K. Fuell[1], and Amy McAlister

[1]Earth System Science Center, The University of Alabama in Huntsville, and [2]NASA MSFC. Contact: rob.junod@uah.edu

THE UNIVERSITY OF ALABAMA IN HUNTSVILLE

SPORT Short-term Prediction Research and Transition Center

Introduction

- Airborne dust can have adverse effects on human heath and activities.
- Near real-time false color Red-Green-Blue (RGB) imagery has been used for dust detection, but it has limitations and can be difficult to interpret, especially during the night.
- The NASA Short-term Research and Transition (SPoRT) center has developed a random forest dust detection (DustTracker-AI) model using NASA/NOAA Geostationary Operational Environmental Satellite-16 (GOES-16) Advanced Baseline Imager (ABI) infrared imagery as inputs.
- SPoRT has partnered with the NOAA National Weather Service to evaluate the model for use in weather forecasting operations.
- DustTracker-AI has shown good agreement with available dust observations

Methodology

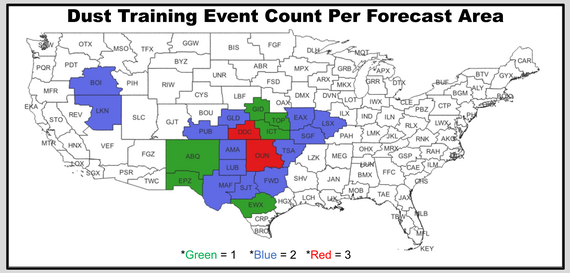
- **DustTracker-AI Model**: Random Forest (Machine Learning)
- **Training Dataset**: GOES 16 ABI imagery was categorized (dust/no dust) by domain experts to create training labels for the model.
- **Inputs**: GOES-16 ABI data, specifically the IR bands, select band differences, and dust red, green, and blue (RGB) components from March 2017 – April 2021
  - 66 cases, 212 distinct images.
  - Cases randomly split into *training (60%), validation (20%),* and *testing (20%)* while maintaining equal temporal distribution.

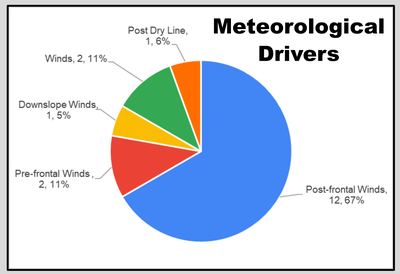
Validation

- Model was validated with similar techniques to *Berndt et al., 2021*.
- **The model correctly labels 86% of dust pixels and 99% of no dust pixels.**
- Both the ROC and PR curves have AUC >= 0.9
- Single pass permutation importance technique adjusted for highly correlated variables was used for identifying features most important to the DustTracker-AI model.
  - Results indicated that 8.4 μm band, 12.3–10.3 μm band difference, 11.2–8.4 μm band difference, 12.3–11.2 μm band difference, and the red and green components of the RGB were the most used relationships for classification. (consistent with physically based remote sensing principals for dust detection)

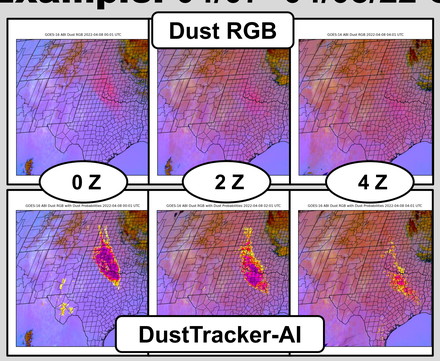
Training Dataset Characteristics:

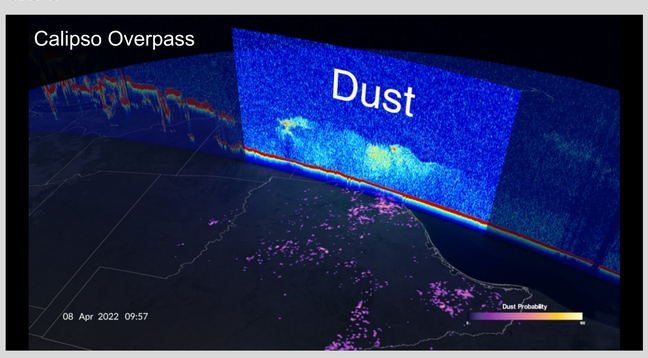
- Most of the Dust training images occur during the Spring season.
- Sustained wind speeds are on average 21.4 knots.
- The model has a focus on synoptically driven events in training, testing, and validation. Which matches the general climatology of blowing dust events in the region but still may lack mesoscale type events within the training.

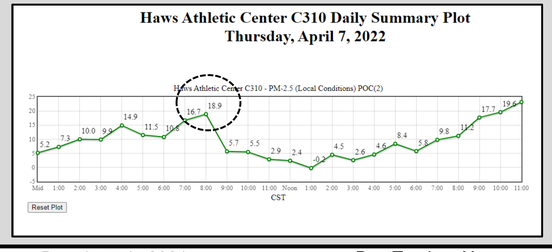


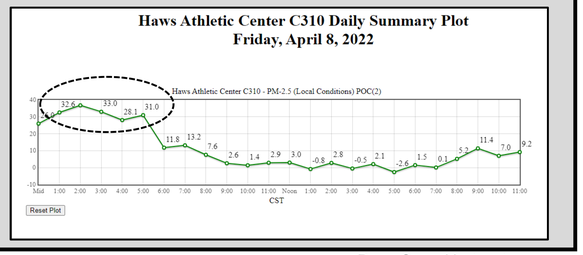


Example: 04/07- 04/08/22 Case









Berndt et al., 2021

DustTracker-AI

HKH Project

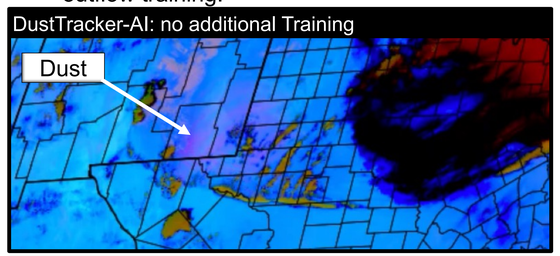
Burn Scar Abstract

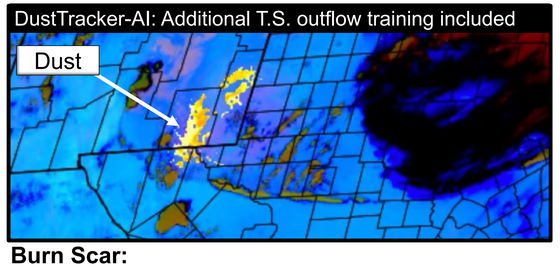
Future/Ongoing Work

- Implementation of model methodology to the Hindu Kush Himalayas (HKH) region.
- Application of methodology to daytime true color imagery for smoke detection in the HKH region.
- Utilize the training dataset and DustTracker-AI as a use case for the Weather & Climate Foundation Model under development by NASA IMPACT and IBM
- Fine tuning of model to capture smaller mesoscale type events such as dust storms resulting from thunderstorm outflow and dust lofted from burn scars.

Thunderstorm Outflow:

- Preliminary work has shown adding training cases with thunderstorm outflow is able to assist in model detection of thunderstorm outflow events.
- Shown below is a thunderstorm outflow event from June 8th, 2022 with the DustTracker-AI with no additional training (top) and the DustTracker-AI with additional thunderstorm outflow training.





Burn Scar:

- Feedback from the NWS has prompted investigation into burn scars as a source region for dust and to determine if Dustracker-AI is able to detect lofted dust from burn scars.